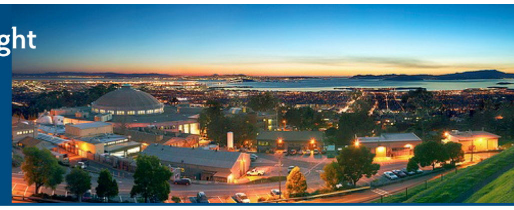
LBNL Materials Sciences Division Research Highlight

U.S. Department of Energy
Materials Sciences and Engineering Division



Two Wrongs *Can* Make a Right

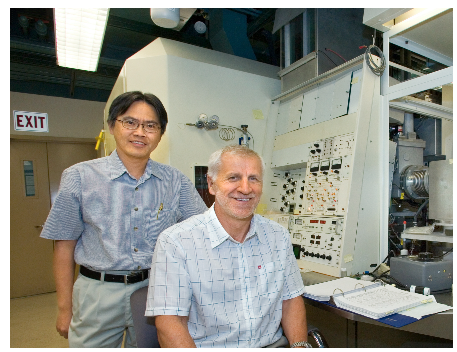
MSD Investigators Wladek Walukiewicz and Kin Man Yu have combined two materials that absorb only the high energy portion of the solar spectrum into a single oxide alloy that absorbs in visible wavelengths. A low-cost highly absorbing material such as this could be used for efficient solar power conversion in solar and photoelectrochemical cells.

> We are exploring ways to make solar cells both less expensive and more efficient; this result potentially addresses both of those needs.

Metal oxides are attractive as components of solar cells as many of them are abundant and inexpensive. However, they tend to make extremely inefficient solar cells because they have wide band gaps and are thus unable to absorb a wide range of energy. In fact, oxides are added to sunscreens to absorb only the ultraviolet sunlight, which is only a small fraction of the full solar spectrum. Therefore, for solar cell applications, narrowing oxide band gaps is essential to allow capture and use of the dominant visible and infrared portion of the solar spectrum and conversion of more of the sun's energy into carbon-free electricity.

Walukiewicz and his team began this search with zinc oxide (ZnO), an ingredient in commercial sunscreens. ZnO has a bandgap of 3.2 eV, which is too wide to absorb visible light. An approach pioneered by Walukiewicz, based on his "band anticrossing" model, predicts that alloying ZnO with a small amount of ZnSe, another semiconductor which also has a "too wide" gap of 2.7 eV, could result in the counter-intuitive result of a drastic reduction of the band gap.

Through collaboration with researchers in LBNL's Energy and Environmental Technology Division, ZnO/ZnSe alloy films were made by pulsed laser deposition. As predicted, alloying ZnO with less than 10% of ZnSe resulted in a semiconductor with a band gap of only 2 eV. It is anticipated that if the ZnSe content could be raised to 52%, a band gap as low as 1.63 eV would be possible with this system; this is close to the ideal value for a low cost, highly absorbing photovoltaic material system



This study opens a new field of research on designer semiconductors that could make a wide variety of naturally abundant, non-toxic materials accessible for solar applications and eliminate our reliance on the rare heavy metals that are currently used in thin film solar technologies. In addition to efficient solar power conversion perhaps the most exciting future application could be photoelectrochemical water splitting, which uses energy from the sun to cleave water into hydrogen and oxygen gases. Harnessing this reaction is key to the eventual production of zero-emission hydrogen powered vehicles, which hypothetically will run only on water and sunlight.

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M.A. Mayer, D.T. Speaks, K.M. Yu, S.S. Mao, E.E. Haller, and W.W. Walukiewicz, "Band structure engineering of Zn)1-xSex alloys," *APL*, 97, 022104 (2010).

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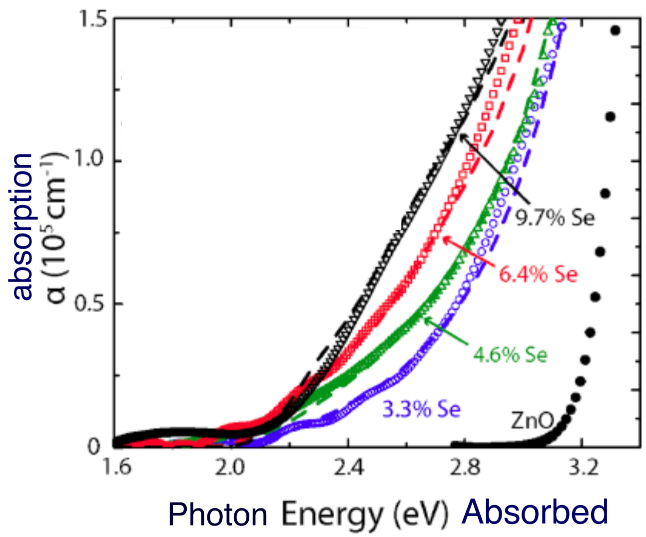

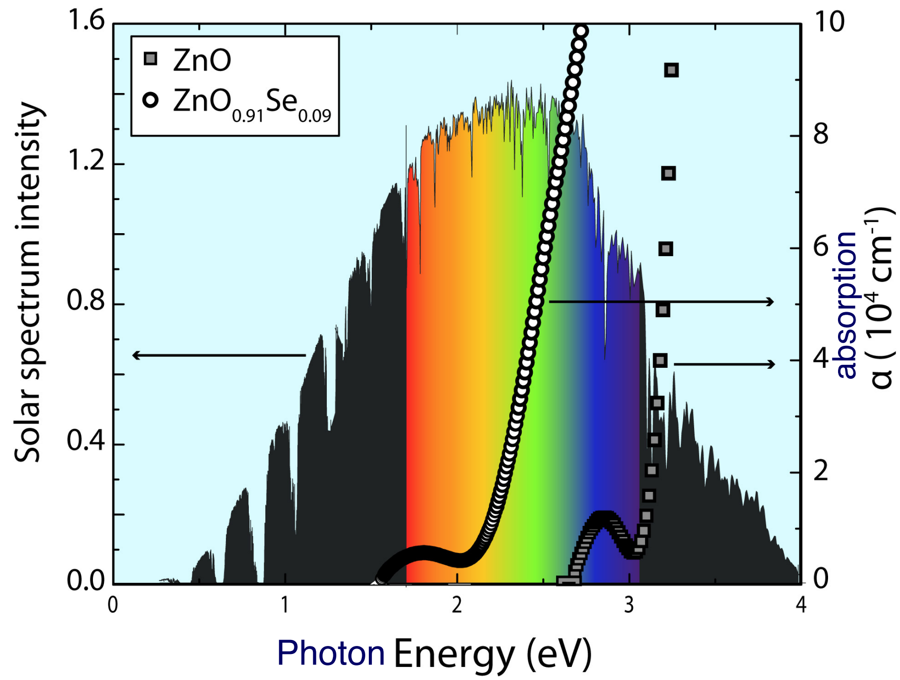

***Addition of small amounts of ZnSe to ZnO) black circles) reduces the material's band gap** which allows significant absorption of light of lower energy (longer wavelength). The shift increases with ZnSe content.*

***The absorption spectrum of ZnO (squares) compared to that of ZnO alloyed with 9% of ZnSe (circles)** overlaid on a standardized plot of the solar spectrum. The ZnSe-containing alloy absorbs significantly more lower energy photons (into the visible range) and a thus a greater portion of the total light.*